

Dynamic Design: A Collection Process

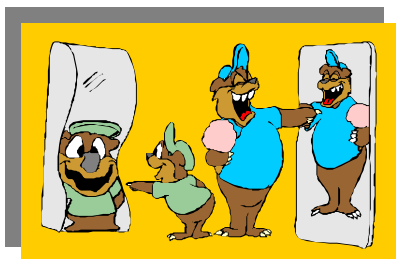
The Concentrator

STUDENT TEXT

The concentrator in the Genesis spacecraft will collect solar wind particles. This device will collect specific elements of solar wind. The concentrator is an electrostatic mirror that is designed to focus solar wind particles on a special chemical vapor deposit (CVD) diamond and silicon carbide surface. This will enable collection of a more dense concentration of oxygen and its isotopes.

MIRRORS

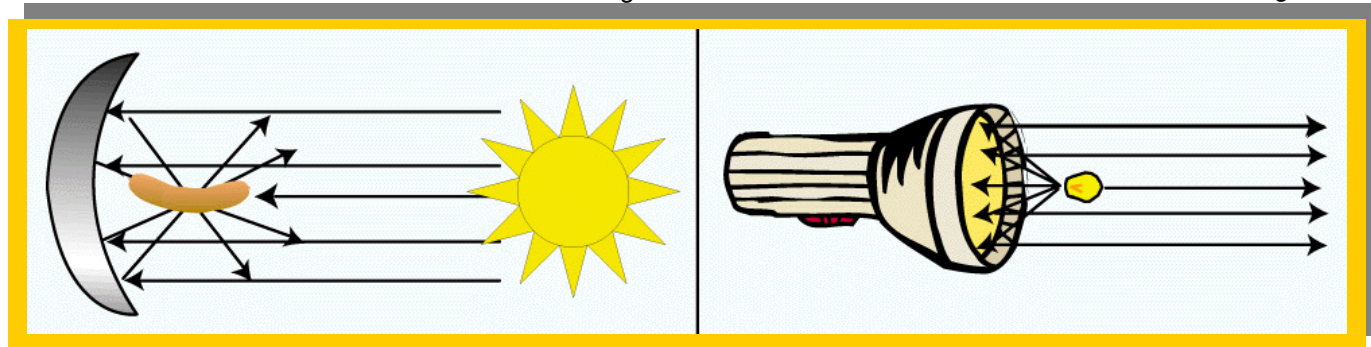
When light hits an object, three things can happen depending on the type of surface that it hits. Light can be transmitted through an object, absorbed into the object, or reflected away from the object. Mirrors are made of glass coated with silver that reflects light, allowing you to see your reflection. There are many shapes of mirrors. Think of a time when you were in a fun house and saw your image in a curved mirror. How did it make you look? Only gentle curves are needed to produce many different effects. The three most common mirror shapes are plane, concave and convex. Plane mirrors have a flat surface and are the kind you might see in a bathroom. Convex mirrors have edges that are bent away from you and are used to make images appear larger. They are often found in stores and as rearview mirrors on cars or trucks. Concave mirrors have edges that are bent toward you and make images appear smaller. Concave mirrors are used to focus light to a point and are used in solar ovens (Figure 1) and flashlights (Figure 2). Solar radiation hitting the ground does not have a high enough density for cooking. But if radiation is concentrated into a small volume, then cooking temperatures can be reached quite easily. There are many techniques for constructing solar cookers. To make your own solar cooker, see the Student Activity "[Hot Dog Cooker](#)." Solar cookers and flashlights both use concave mirrors but in opposite ways. A solar oven directs the light from the sun to the focal point to cook food. In a flashlight, the light at the focal point is reflected outward by the concave mirror behind the light bulb resulting in parallel light rays.



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Figure 1

Figure 2



Solar cooker with hot dog at focal point

Flashlight with light bulb at focal point

To see an animated explanation of the physics of concave mirrors go to:

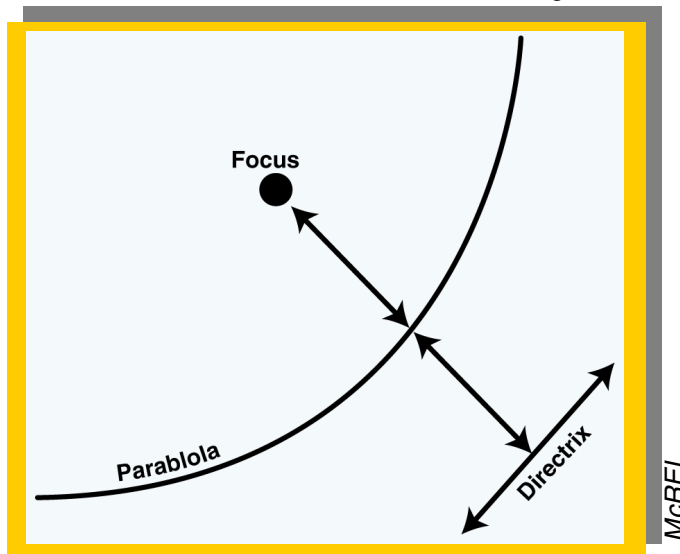
<http://www.glenbrook.k12.il.us/gbssci/phys/mmedia/optics/ifcma.html>

PARABOLAS

Concave mirrors are also known as parabolic mirrors. In a plane, any curve consisting of a set of points equidistant from a line and a point not on the line is a parabola. On the diagram at right the line is called the directrix, and the large dot is called the focus. The standard equation of a parabola is $y = x^2$. A paraboloid is a three dimensional parabola. A simple example of a paraboloid is the concave side of a spoon.

Parabolic mirrors are used in many instruments; some include reflector telescopes, spectrometers, and lasers as well as flashlights and solar ovens. One common use is in satellite dishes. The purpose of a satellite dish is to collect a signal from a satellite and focus it onto a receiver. From physics it is known that the angle of incidence is equal to the angle of reflection. The paraboloid is a good shape for a satellite dish because its surface reflects the incoming signal to the receiver from every point on the dish surface. Every signal from the satellite that strikes the dish and is reflected to the focus travels the same distance regardless of where it strikes the dish. This assures that all signals reach the focus "in phase" and do not interfere with each other.

Figure 3



THE CONCENTRATOR

Figure 4



The job of the concentrator on the Genesis sample return capsule is to repel hydrogen protons and to enhance the density of heavy ions, particularly oxygen that will be collected. The concentrator (see Figure 6) is made up of three basic components: the entry grid, the mirror grid, and the target material. The entry grid is made up of three layers. The entry grid repels protons and straightens the trajectories of heavier ions. How would you design a grid that would repel protons and allow other solar wind ions to enter? Why would the Genesis scientists want to repel protons? (HINT: Most solar wind is made up of...) The entry grid is made up of three entry grids that are convex and attached by an "embroidery hoop" around the circumference. Once through the entry grid, the ions are straightened before being reflected by a parabolic mirror.

The second component, the mirror grid, is made up of 30 pie-shaped sections that have a backing plate underneath them. The mirror grid has an electrode surface under each mirror that reflects the ions toward the target. The electrode surface consists of a series of micro-steps that reflect photons out of the concentrator so that the sun's light does not hit the target.

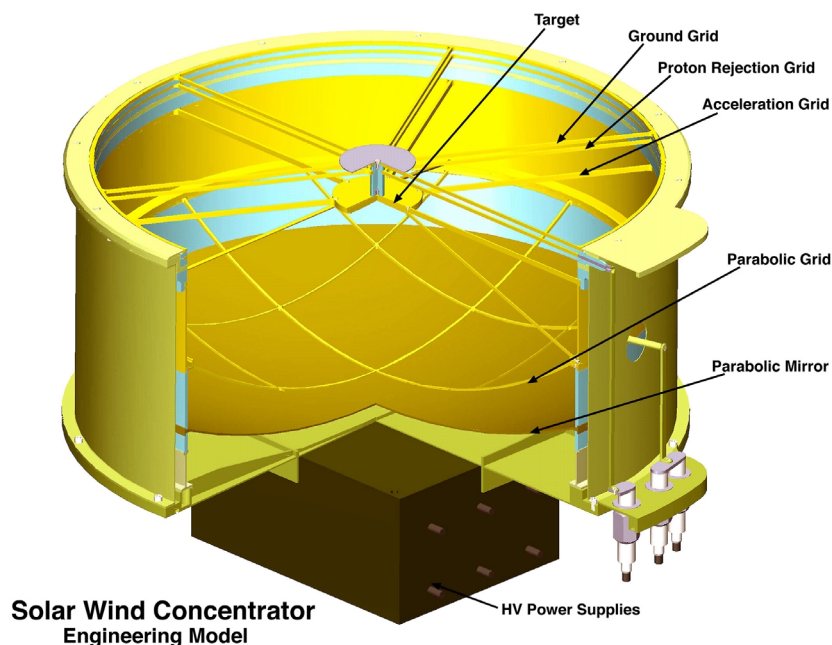
The third component, the target, is made of CVD diamond film that was specially designed for the Genesis mission. Concentrator models were tested at the University of Bern, California Institute of Technology, and Los Alamos National Laboratory. One test used 50 million trajectories to map ions to ensure the proper focal length for the target. The concentrator will provide for a more specific type of solar wind to be brought back to Earth for analysis. Discuss with your group how this new technology and design will enable scientists to study the solar wind in ways that have never been done before.

Figure 5





Figure 6: Labeled Diagram of the Concentrator



Los Alamos National Laboratory

After reading about the Genesis concentrator, make the model as described in the laboratory procedure. When you finish, think about what aspects of the model that you made are accurate representations of the actual concentrator? How is it inaccurate?

RELATED WEB SITES

<http://accept.la.asu.edu/PiN/opticskit/expt/expt9.shtml>

Optics Discovery Kit Experiment #9: MIRRORS

<http://forum.swarthmore.edu/dr.math/problems/miyasaki6.3.97.html>

Parabolic Mirrors and Telescopes

<http://mathcentral.uregina.ca/RR/database/RR.09.95/weston1.html>

Why are satellite dishes parabolic?

<http://www.glenbrook.k12.il.us/gbssci/phys/Class/refln/u13l3a.html>

Physics Classroom Reflection Lesson

<http://solarcooking.org/plans.htm#parabolic-style>

Procedures for making your own solar cooker

<http://www.jyu.fi/~hvirtane/con1.html>

Procedures for making your own solar cooker